TOWARDS A NEW BIOMIMIC APPROACH, NEW BIO-MIM-TRIZ DESIGN PROCESS

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Abstract— Humans with their destroying habits are leading the nature to its decay and leaving us with worries about the built environment and natural resources. Therefore, in order to strengthen the relationship between person and place, architects should find new solutions and approaches that cope with nature and work perfectly with it. It is important to have a deeper look on nature that has a huge database of solutions for all problems and created several ways and techniques to guarantee this survival for many years. This can be achieved by biomimicry, but due to the appearance of a problem that faced the designers which is their limited knowledge of biology, another approach was needed. Here comes the role of Bio-TRIZ that appeared to help the architect to extract solutions easily from nature but again there was a problem addressed in the differences in engineering and biological terminologies. Therefore, this paper derives a new design process that combines biomimicry with Bio-TRIZ, leading to "BIO-MIM-TRIZ" and it leads to new "BIO-MIMIZ" buildings. This new process can help designers develop candidate bio-inspired engineering products or solutions for a given problem. The goal of this evolutionary architecture is to achieve symbiotic behavior and metabolic balance in the built environment as they are the main characteristics of the natural environment and optimum life.

Keywords— Biomimicry, Architectural design process, Bio-TRIZ, BIO-MIM-TRIZ, BIO-MIMIZ buildings.

I. INTRODUCTION

This paper will start by reviewing some of the design processes, biological design process and Bio-TRIZ design process, showing strong and weak points in each of them. One might ask about the reason for explaining these designs instead of reviewing the new design process only. The answer is that to understand the new process, it is important to understand first the basics that created this process in order to understand its progress and the best way to apply further progression. This will help the reader to understand each one individually and then understand differences between them to reach a conclusion that the Bio-TRIZ design process is the best one among them.
Authors end this paper by a comparison between biological and Bio-TRIZ design process, showing pros and cons in each.
It is necessary to link the design process with nature and future, or else the qualifications of our design and building culture will demolish by time and prevents architects to achieve sustainability, energy efficiency, healthier environment or solar optimization. The riddance of that is to create a new designing process with various tools and equipment to guarantee the right of our coming generations to enjoy our pure nature.
On the other hand, there is a misplaced belief that Biomimicry is generated through the manipulation or purification of a natural form and surroundings. This misunderstanding of its real goals and principles led most architects and designers to fail in achieving its goals. They wrongly thought it is all about learning from nature, forgetting that is also about willing to work closely and incrementally with it, rather than as manipulators. Not realizing that mimicking natural form or appearance alone misses the point, architects didn't pay attention to observe nature, allow it to teach us about itself and understand the way it survives and adopts.

It is important to search in nature as it is capable to shape the future by emulating nature's time-tested patterns and strategies, and then use them to solve human problems in every field of like especially architecture. The new BIO-MIM-TRIZ will contain its own huge database will allow architect to extract hundreds of solutions for any problem. It will introduce them according to the selected feature that the architect desire to achieve in his design. BIO-MIMIZ buildings goal is to learn from nature and reach the best ecological performance and processes to reach sustainability by new invented ideas.

II. BIOLOGICAL THINKING & BIOMIMICRY

The word biomimicry originates from the Greek word bios, meaning life, and mimesis, meaning to imitate. Biomimicry is the study from nature to solve problems in design, business and life (Rao, 2014). Biomimicry is not relatively new as some designers and people think, but the misunderstanding of its principles is the reason for not using it worldwide. We eagerly need designers who engage nature more deeply than merely mimicking natural form. These designs will help people to develop a deeper, more responsive understanding of nature and place in order to instill a genuine sense of belonging. Or else, many design

proposals will be unsuccessful and incomplete (klein, 2009).

In conclusion, reaching authenticity in biomimicry won't be achieved unless reaching wholeness in form and understanding nature's survival, human needs, traditions and existing environment. This wholeness can be achieved by four essential points: first, the natural form should be derived from its surrounding and bond with it; second, that the engagement with natural form should be use-based rather than image-based; third, the natural form should satisfy everyday needs of its inhabitants and be comfortable for the usage and appropriate for their proportion; fourth, the criteria when mimicking a natural form is mimicking its natural process. On the other side, interior comfort should be also achieved and considered in design beside the wholeness in exterior form. This will take place when considering inhabitant's proportions and observing their needs in spaces which our ancestors already discovered and studied, like Leonardo's Vitruvian man and le Corbusier Modular, all shown in figure 1.

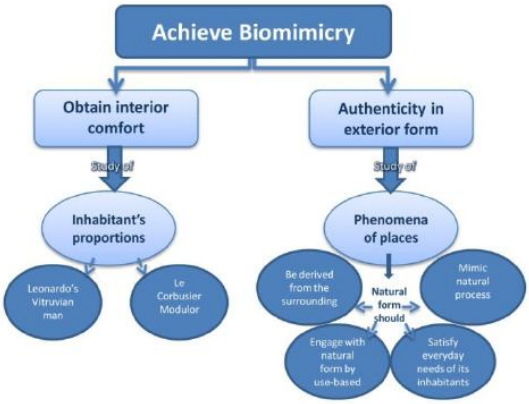


Figure 1 Determinants to achieve biomimicry

III. HOW BIOMIMICRY CHANGES OUR LIFE?

To understand the benefits of biomimicry, there are three aspects that should be put into consideration. These aspects are looking up to nature as model, measure and mentor. As Mentor is to view nature not as a possession, but as a teacher, Measure is when we can use nature as an ecological standard to measure the fitness of our own designs and model is knowing that Biomimicry studies nature's models and emulates these forms or processes (Royall, 2012)

Biomimicry is a very interesting science that has the ability to save architecture and nature from the built environment. It depends on the fact that living organisms and engineers have the same goal: creating a structure in the cheapest possible way- either in terms of money or energy (Elsharkawy, 2011).Biomimicry can be applied to architecture and buildings in three fundamental ways:

(1) To make stronger, tougher, self-assembling, and self-healing materials;

(2) To use natural processes and forces to accomplish such basic building functions as heating and cooling; and

(3) to produce resources, rather than drain them, by using/applying the biomimicry principles of zero waste and co-evolution (Koelman, 2003).

IV. APPROACHES TO BIOLOGICAL DESIGN

A. Problem-based approach

This design approach carries different names and they all refer to the same meaning, such as "Design looking to biology", "Top-down approach", "Direct approach" and "Problem-driven biologically inspired design".

This direct method of investigation contains several steps illustrated in figure 2, starting by scoping, where the designer defines the design problems and the context of its creation and use. After understanding the problem and design requirements, it is time for idea-generation through retrieving inspiration and engineering solutions from nature. When searching the natural world for examples, it is useful to investigate an array of divergent organisms that rely on different approaches to solve similar problems. This will help us to see which has the best / most relevant strategy and yield a greater variety of ideas with which we develop. The final stage is engineering and evaluation by translating the best strategy to a buildable thing, putting guidelines criteria for product engineering and reaching the optimum solution for the design problem (Panchuk, 2006).

B. Solution based approach

As stated in the previous approach, this approach was also found to have different naming such as "Biology Influencing Design", "Bottom-Up Approach", "Indirect approach" and "Solution-Driven Biologically Inspired Design". It begins with a biological solution that is defined, understood, reframed and then found problems to which the principle could be applied, as shown in figure 3.

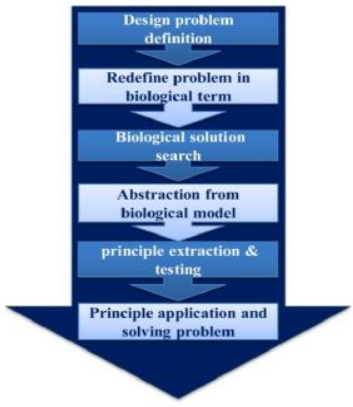


Figure 2 Top-Down Design Approach



Figure 3 Bottom-Up Approach

V. Bio-TRIZ

Bio-TRIZ is the methodology that has been developed analyzing 500 biological phenomena covering more than 270 functions; they analyzed more than 2500 conflicts and their resolutions in biology ranked by level of complexity (Trotta, 2011). Bio-TRIZ is a designing process, resulted from combining Biomimicry and TRIZ together, that helps generate biological solutions and information. It is believed that this approach will facilitate the concept development phase for any entrepreneur looking for a creative, innovative, efficient solution to a problem (Weaver & Kleinke, 2012).
Bio-TRIZ is a systematic process that allows architects team, without any need of biologists, to extract biological solutions and inspirations for any design problem. This takes place by following the steps of TRIZ methodology to help introduce biological principles on buildings.

A. Bio-TRIZ Principles

The blending of TRIZ and biomimicry helped a lot so that, when a designer utilizing the TRIZ methodology is referred to the relevant TRIZ principles with man-made examples of the application of those principles, he/she is also referred to some biological examples that illustrate those same principles. This will inherently serve to expand the scope of the design space under consideration to include biologically inspired solutions without a separate and distinct process to do so. TRIZ embodies a number of principles that appear surprisingly compatible with Biomimicry (Hoeller, 2004):

It bridges the abstract (academics) and the concrete (technology).

- Embraces conflicting requirements as a positive force in problem solving.
- Encourages efficient use of resources.
- Recognizes limits, including turning drawbacks into useful resources.
- Focuses on understanding problems as a system.
- Aspires to identify an ideal solution.

BioTRIZ modifies the TRIZ matrix but maintains the same principles to solve different conflicts or problems. Their analysis of 500 biological phenomena showed that the 40 TRIZ principles (identified from studying engineering patent databases) were used by nature to solve design problems or conflicts. The problem is formulated in terms of two contradictory features selected from a list of 39. Each of these features belongs to one of six meta- categories: substance, structure, energy, information, space, and time which together form the basis of the 6x6 Bio-TRIZ look-up tables. The question that introduces itself here is; what if the design problem is not based on a contradiction? If the problem is simply defined and needs a solution from nature, Bio-TRIZ won't be able to extract this solution. Comparing biological and Bio-TRIZ design processes helped us to understand the role of the new design process and draw the main outlines of it. Using the pros and cons in each will help creating the new BIO-MIM-TRIZ (Freescale Semiconductor, 2005).
Therefore Bio-TRIZ design process cannot be used unless the presence of a physical contradiction that takes place between two physical requirements to the sane parameter of an element in this design process. This will allow architects to achieve biological solutions that will solve the design problem.

B. How to solve problem using Bio-TRIZ?

The biological effects database, the PRIZM matrix, and the biomimetic TRIZ matrix added to the classic TRIZ framework provide a powerful toolset for the development of biomimetic solutions. They provide tangible and detailed access to natures solutions without requiring the involvement of a trained biologist. We need to show that the introduction of biology into TRIZ does not compromise its ability to solve engineering problems and yet makes it compatible with the natural solutions to various problems from biology. The sequence of solving the problem is introduced in figure 4 (Korecki, 2008).

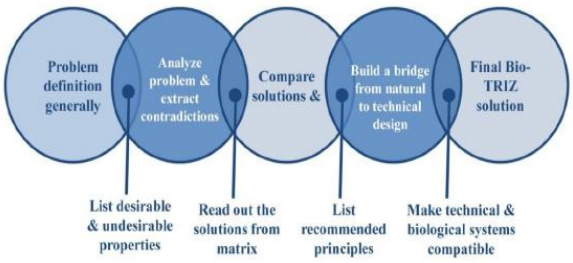


Figure 4 the steps of solving design problem using Bio-TRIZ

VI. NEW BIO-MIM-TRIZ DESIGN PROCESS

The main lines of this new BIO-MIM-TRIZ design process will appear by two main methods. The first method is a comparison between biological and Bio-TRIZ design processes, extracting their goals, designing tools, principles, approaches, pros and cons. This will help us extract the outlines by developing good points, avoiding all defects and finding solutions for them to. The second method is creating new principles and features that will lead to a new developed and unique design process. This will lead us to a new design process that overcomes the defects in each of them and works efficiently to extract biological inspirations easily.

A. What is BIO-MIM-TRIZ?

The BIO-MIM-TRIZ design process is based on nature with its infinite variety of shapes, colors and species where the only imperative for living in harmony with nature is mutual respect. Architects enjoy many biological forms, are impressed by their abilities, and are inspired and stimulated by their designs, patterns and structures, then it is logical to see what biology has to offer in terms of design for the engineering purposes of humanity. Living organisms provide inspiration for innovations in many different fields and for entirely different reasons. Therefore the BIO-MIM-TRIZ process will implement the usage of biology in architecture.

This new Bio-MIM-TRIZ process observes nature to find solutions, not based on contradiction and also helps architects to use nature without a help of biologist is needed. So that it will contain tables that carries all problems faced in nature and their resolutions in biology ranked by level of complexity. This design process is due to the development of biological and Bio-TRIZ design processes and will lead to BIO-MIMIZ buildings that achieve goals, principles and features explained in the following section.

B. BIO-MIM-TRIZ goals

A comparison between the design processes is held to understand goals and requirements in table 1 in order to lead the authors to the main goal of BIO-MIM-TRIZ process which is making the biological information available to engineers by cataloguing and classifying the effects of any giving action, mechanism or function in all biological systems. The requirements are like the working team and inputs of the design process, but the common essential requirement found in all processes is respecting and taking into consideration the human scale and proportions. The optimum design will never be reached unless it is well designed to suit the inhabitants and achieve the ultimate comfort. This will lead to a strong relation between buildings, its occupants and the environment.

Table 1: Comparison between biological and Bio-TRIZ design processes (goals & working team)

Biomimicry/ Biological design process	Bio-TRIZ design process
Goal	
Biomimicry seeks design inspiration from nature.	Bio-TRIZ seeks design inspirations from nature, but in an easy and systematic way.
Working team	
Architects and biologists must work together, where architects find the design problem and biologists search for solution in nature. The biologists then deliver the optimum solution to architects in order to continue their design.	Architects can work alone because Bio-TRIZ provide them with a systematic innovation that is designed to help a team or individual generate a large number of concepts in the hopes that one or a few of those concepts will be winners

C. BIO-MIM-TRIZ principles

Each successful design process should have a main principle that the whole process is based on and other sub principles gathered together to help reaching this main one like in figure 5. In BIO-MIM-TRIZ process the main principle is the idea that “Each problem surely has been faced before in different aspects, so it is all about finding these solutions and adapting the most convenient one to the design”. This means that by searching in nature we will surely find a similar problem with a tried effective solution. There is a number of sub-principles can be defined as following:
Problems and solutions are repeated across industries and sciences.
Patterns of technical evolution are repeated across industries and sciences.
Innovations were developed when using scientific effects outside the field.
Abstracts (academics) and the concrete (technology) are bridged together.

- Encourages the efficient use of resources.
- Recognize limits including turning drawbacks into useful resources
- Focuses on understanding problems as a system
- Aspires to identify an ideal solution.

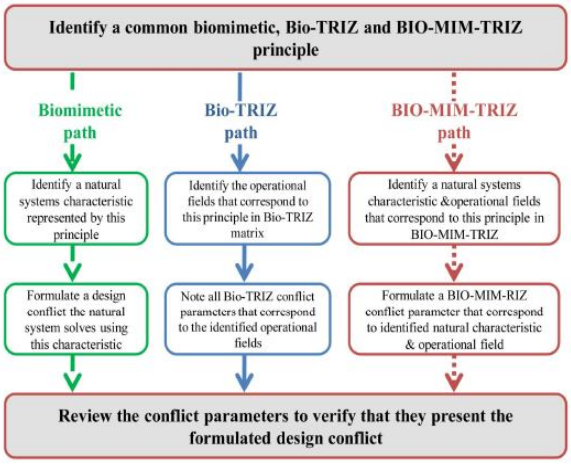


Figure 5 Reviewing the biomimetic and BIO-MIM-TRIZ in the context of Bio-TRIZ matrix

D. BIO-MIM-TRIZ designing tools

Every design process has many tools that are used by the designer to facilitate the analysis of the problem and the search for solutions. The purpose of using these tools is reaching the best solutions in the shortest time. The main tool that is used in BIO-MIM-TRIZ process is the knowledge and information gathered from nature and old experiences. This tool will allow us to collect generate a table of four sections, the first and second sections will contain weather and location to introduce the geographic, humidity, temperature and many other aspects that specific place of the project. The third section will introduce all features that can be applied in architecture like structure system, building skin, illumination system, ventilation and many other properties. Finally the fourth section will include all means, derived from animals, plants and nature, which can achieve each feature.

Knowledge is considered the main tool in the BIO-MIM-TRIZ design process, as it forms the huge database of problems and solutions on which the process perform. There are four stages for using this tool, at it starts with analyzing the problem in a well-structured form. After analysis phase, there is the extraction one where all solutions that has been used to solve this specific problem before will be extracted from nature and collected in a scientific form. . The fourth and final phase is testing, where the chosen solutions are compared together and the optimum one is extracted tested and applied.

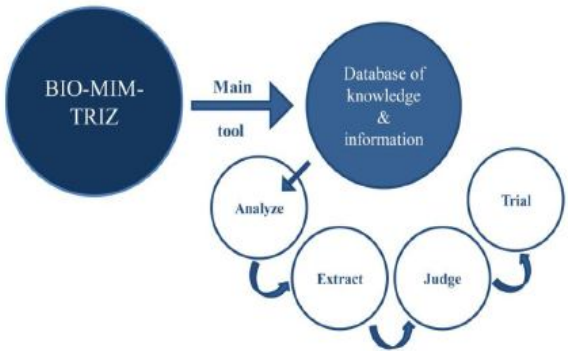


Figure 6 BIO-MIM-TRIZ designing tools

VII. EXAMPLE APPLYING BIO-MIM-TRIZ DESIGN PROCESS

Considering illumination system as the feature needed to be achieved in building. The BIO-MIM-TRIZ plug-in will start searching the data base for all similar features derived from nature. It will find that under animal classification, there is the:

- Peacock: refract light and produce light hues. Also, there is the
- Beetle: has the ability to control light by controlling air in breathing tubes
- Fireflies: produce green-yellow light through a very efficient process
- Butterflies: manipulate light and ability of coloration.

Also under plants classification, it will show plants that are sensitive to light and can close and open pedals according to light. Finally from nature, there will be the human eye and its light-trapping process.

The new BIO-MIM-TRIZ design process will contain a huge database of features that can be applied on buildings and on the opposite side all animals, plants and nature that has adapted the same feature millions of years ago and was the reason of its survival. This will lead to BIO-MIMIZ buildings that cope perfectly with nature, engage with built environment and save it from destroy.

CONCLUSION

It is important to ask ourselves why should architects and designers look to nature for inspiration and imitate it and the reason is that it already has many solutions to our problems. The natural world is the source and subject of nearly all human knowledge and its beauty is derived from its functionality more than outer form. So looking on nature is the first step that architects should take for improving their current designs, solve the inefficiency and loss of place problems (Yowell, 2011).

Environmental designers should know that observing nature's best ideas and imitating designs are the way to solve human problems, protecting natural resources and saving energy. But that doesn't mean to mimic natural forms without taking attention to their behaviors, wholeness in form and willing to work closely and incrementally with them. Extracting and understanding the natural behaviors and biological aspects is difficult on architects due to their limited knowledge of biology and the differences in engineering and biological terminologies are the two main problems in using this process.

As for Bio-TRIZ design process, it tried solving the problem facing biological design process by creating a table that helps architects, after the exact definition of problem contradictions, to search in nature by themselves. Architects in this process don't need any help from biologist and can easily extract solutions from nature and choose the optimum one to apply on design. The problem in this design process that makes implementing Bio-TRIZ on a project is as said before, based on contradiction.

After reviewing various design processes, the authors concluded that each of them has its own defect that prevents it from performing perfectly and giving the desired results. These defects led us to search for a new design process that overcomes these flaws and helps in reaching the main goal of nature and biology inspired designs. This new essential tool is called BIO-MIM-TRIZ design process, based on Mother

Nature as a master designer and seeks design inspiration from nature. Therefore, there will be to BIO-MIMIZ buildings introduced to architecture, a new buildings type carrying its own features, achieving specific goals. This will be a save to architecture and natural resources, leading to enhance of human beings and better relation between person and place.

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